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seas which lie beneath them, where living things unknown to warmer climes congregate in unimaginable multitudes. There is life all over the solid earth; there is life throughout the vast ocean, from its surface down to its great depths, deeper still than the lead of sounding line has reached.

And it is with these living hosts, unbounded in their variety, infinite in their numbers, that the student of biology must make himself acquainted. It is no light task which lies before him — no mere pastime on which he may enter with trivial purpose, as though it were but the amusement of an hour; it is a great and solemn mission to which he must devote himself with earnest mind and with loving heart, remembering the noble words of Bacon: —

"Knowledge is not a couch whereon to rest a searching and restless spirit; nor a terrace for a wandering and variable mind to walk up and down with a fair prospect; nor a tower of state for a proud mind to raise itself upon; nor a fort or commanding-ground for strife and contention; nor a shop for profit and sale; but a rich storehouse for the glory of the Creator, and the relief of man's estate."

REVIEWS AND BOOK NOTICES.

THR SYSTEMATIC POSITION OF THE BRACHIOPODS.* — To those accustomed to find the Brachiopods invariably mentioned in palæontological as well as zoological works as shell-fish, with no hint of an affinity to any other class of animals, the author's remark at the beginning of his essay that "the Brachiopoda are true worms, with possibly some affinities to the Crustacea, and that they have no relations to the Mollusca, save what many other worms may possess in common with them," will seem in its nature somewhat iconoclastic. But we should remember that Cuvier regarded the barnacles as Mollusca, and it was not until 1830 that Thompson and Burmeister demonstrated from their mode of growth that these shell-bearing animals were undoubted Crustacea; the Serpulæ and Spirorbes were regarded as shell-fish by many collectors, and even the bivalve phyllopods (Estheria) of our fresh-water pools are daily mistaken by collectors for species of Cyclas. On the other hand certain worms, such as the flat worms or Planarians, have been regarded as allied to the snails and slugs by good naturalists.

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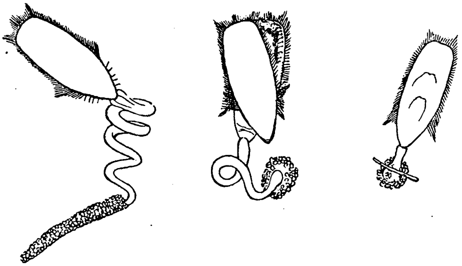
*The Systematic Position of the Brachiopoda. By Edward S. Morse. (From the Proceedings of the Boston Society of Natural History, xv. Published August, 1873. 8vo. pp. 60.)

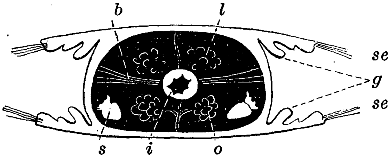
Fig. 1.



Lingula pyramidata.

We will now attempt, so far as is possible, to condense the paper of Professor Morse by giving his chief arguments for considering the "Lamp-shells" as worms. He first defines the two classes. The worms have an elongate form, while that of the

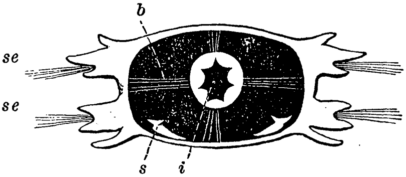
Fig. 2.



Transverse section of Lingula.

b, bands suspending intestine in perivisceral cavity; *i*, intestine; *s*, segmental organ; *o*, ovaries; *l*, liver; *g*, gills; *se*, *se*, setæ.

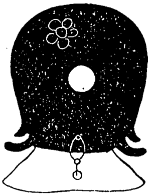
Fig. 3.



Transverse section of Annelid, after Carus.

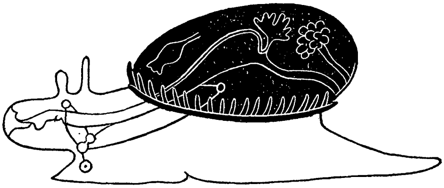
b, bands suspending intestine in perivisceral cavity; *i*, intestine; *s*, segmental organ; *se*, *se*, setæ.

Fig. 4.



Transverse section of molluscan archetype, after Carus.

Fig. 5.

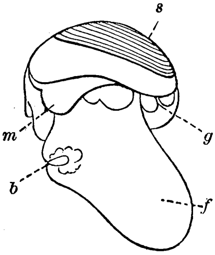


Molluscan archetype, after Carus.

mollusk is concentrated or sac-like; hence the term Saccata applied to them by Professor Hyatt.

In the mollusk the viscera are usually contained in a large chamber protruding above the foot, while in the worm "the symmetry of the body is never disturbed by the viscera." In the mollusk, moreover, the mantle is sac-like, "inclosing a conspicuous cavity," and protecting the gills, while the alimentary canal is straight in the worm, rarely convoluted, and suspended freely in the perivisceral cavity, by bands (Fig. 1, b); in the mollusk this organ is always convoluted, and intimately blended, or united, with other organs. The nervous system of the worms consists of a nerve collar from which start two parallel chains of ganglia, while in the mollusks there is a nerve collar, but no double chain, and instead, nerves are thrown out to the sensory, motor and parieto-splanchnic regions. The eggs of worms are usually (except in the leeches) set free in the general cavity of the body, which is not the case with the mollusks. Lastly, the embryo mollusk (Fig. 6) early develops a shell composed of one or two pieces, while the embryonic worm is usually distinctly ringed, as seen on the opposite page.

Fig. 6.



Embryo of Lamellibranchiate.

s, shell; *m*, mouth; *f*, foot; *b*, byssal gland; *g*, gills.

Here, in passing, we would remark that while the mollusks are admirably characterized, the author has, we think, failed to give sufficient importance to the most fundamental and important character in the typical worm. Certainly the ringed, segmented structure of the worm is that which, more than any other character, separates it from other animals, and when the rings are absent, as in the Planarians, Nematoids and other low worms, this is an adaptive character resulting from their peculiar habits. Moreover it should be remembered that our author regards the Brachiopods as a division of Chætopod worms, in which the segments are invariably present, and form the most important feature of those animals. Again, we fail to find any reference to the relation of the most important anatomical systems (the nervous, circulatory system and digestive canal) to the walls of the body. The correlation in structure of the nervous system of the higher worms to the segmented structure is also most intimate and remarkable.

Fig. 7.

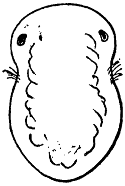


Fig. 8.

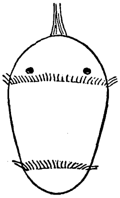


Fig. 9.

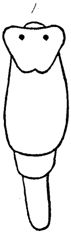


Fig. 10.

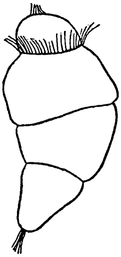
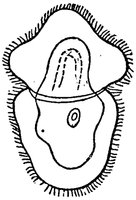


Fig. 11.



Embryos of Worms.

Fig. 7, Serpula; Fig. 8, Spio; Fig. 9, Melicerta (Rotifer); Fig. 10, Pileolaria; Fig. 11, Phoronis; (Fig. 7, original; Figs. 8 and 10, from Claparède; Fig. 9, from Huxley; Fig. 11, from Dyster.)

Fig. 12.

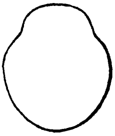


Fig. 13.

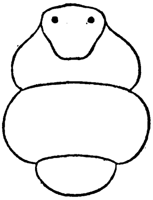


Fig. 14.

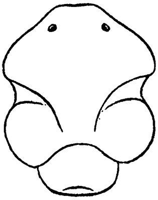


Fig. 15.

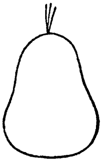


Fig. 16.

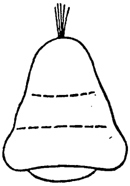
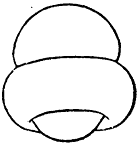


Fig. 17.



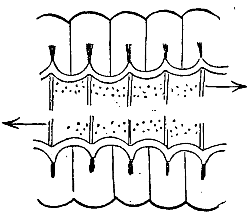
Embryos of Brachiopods.

Figs. 12, 13, 14, Thecidium (from Lacaze Duthiers).

Figs. 15, 16, 17, Terebratulina (original).

To this deficiency in the definitions, otherwise so full, we shall recur in noticing the author's conclusions as to the more immediate relationship of the Brachiopoda. It may also be noticed that in none of the diagrams of the transverse sections of the worms are the positions of the dorsal vessel or nervous cord in relation to the body walls indicated; and in this respect the same view of the mollusk is unsatisfactory. This is said not so much by way of criticism, as to call attention to important differences between the Brachiopods and Chætopodous worms, which demand serious consideration in accepting the conclusions as to the precise systematic position of the Brachiopods claimed by the author.

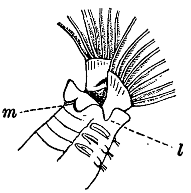
Fig. 18.



Portion of Peduncle of *Lingula pyramidata*, showing annulations, and circulation of fluid within.

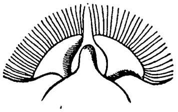
Farther on, in speaking of the general proportions of the body, it seems that the author does not lay much stress on the ringed structure of the higher worms, of which it should be borne in mind he considers the Brachiopods to form a division. Thus it is stated, almost casually, that "a prominent character of the higher worms is the annulations or rings marking the body." As, however, the annulations are wanting in certain low worms (*i.e.* the Gephyrea or Sipunculoid worms, Sagitta, Nematoidea, Acanthocephala*) the absence of this character in the Brachiopods is unimportant; still, however, the peduncle of Lingula is "partially annulated" (Fig. 18).

Fig. 19,



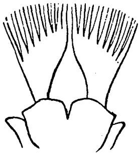
Showing cephalic collar of Sabella. *m*, median dorsal notch; *l*, lateral notch.

Fig. 20.



Head of Discina.

Fig. 21.



Head of Sabella.

The comparison between the mollusks and worms is then extended to the integumentary organs. Here, in an exceedingly suggestive way, the author shows that in the worms the integument is rarely ever extended beyond the limits of the body; but when it is it forms a broad cephalic collar, "covering the base of the arms in those worms possessing it (as in Sabella, Fig. 19), while in the Brachiopoda the collar covers and protects the arms," and this collar is not to be compared with the mantle of mollusks. On page 27 the cephalic region of the true worms is discussed, and the intimate relationship between the head of certain worms, such as Sabella and Amphitrite, and that of the Brachiopods, shown. This can be seen by a glance at the accompanying figures. We cannot farther abstract the condensed statement of the author. By making a longitudinal section of the worm Amphitrite, and the brachiopod Lingula, the most interesting relationship may be detected (Figs. 22 and 23).

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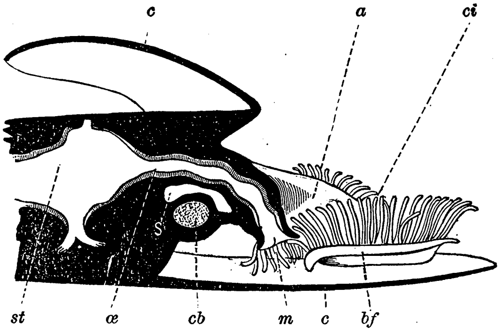
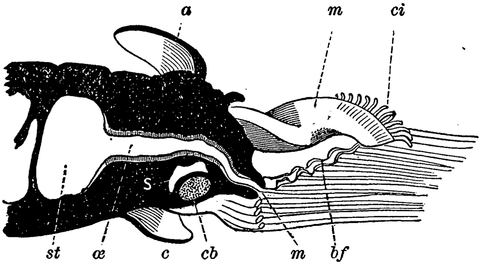
*It should be borne in mind that these worms are mostly parasitic, or, as in Sagitta and Sipunculus, very aberrant forms, and the absence of rings is probably a secondary or adaptive character.

Fig. 22.



Longitudinal section of anterior portion of Lingula.

Fig. 23.

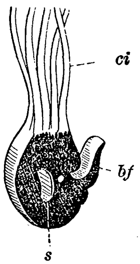


Longitudinal section of anterior portion of *Amphitrite ventrilabrum.*

m, mouth; *œ*, œsophagus; *st*, stomach; *a*, arm; *ci*, cirri; *bf*, brachial fold; *cb*, cartilaginous base of arm; *s*, sinus leading to arm; *cc*, cephalic collar or pallial membrane.

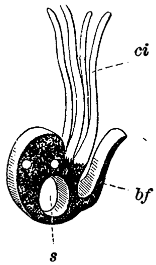
Considering the arms alone we are told that a transverse section of a right arm of Amphitrite (Fig. 24) resembles that of Lingula, (Fig. 25) much more than "corresponding sections of two Brachiopods resemble each other."

Fig. 24.



Transverse section of arm of *Amphitrite ventrilabrum.*

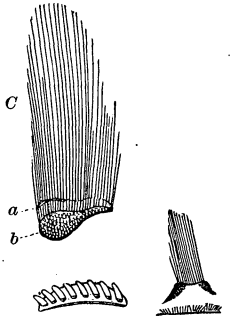
Fig. 25.



Transverse section of arm of *Lingula pyramidata.*

ci, cirri; *bf*, brachial fold; *s*, sinus.

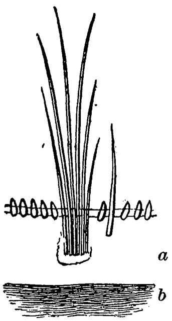
Fig. 26.



Chiton spiculosus, Gray.

A, side view of Chiton, magnified; *B*, side view of one tuft of bristles in the girdle; *C*, a tuft of bristles largely magnified; *a*, line of girdle; *b*, base of tuft.

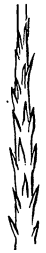
Fig. 27.



Amicula Emersonii.

a, cartilaginous layer; b, muscular layer.

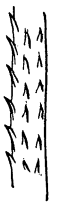
Fig. 28.



Nerine cirratulus.

Deciduous seta of larval worm, *Nerine cirratulus*, from Claparède.

Fig. 29.



Discina.

Deciduous seta of larval Discina, from Fritz Müller.

Bristles like those of worms, moved by muscles, and quite unlike the stiff spines of the Chitons occur in the Brachiopods. The muscles of the integument bear the closest resemblance to those of worms. The perivisceral cavity is shown to be, like that of worms, lined with a delicate membrane and strongly ciliated. Prof. Morse has succeeded in finding a vessel on the dorsal surface of the intestine of Lingula, but not the vesicle described by Hancock. But still he, as well as others, has never succeeded in studying the vascular system satisfactorily. He, however, alludes to a pseudo-hæmal system of organs, being a set of membranes which invest the oviducts, and has traced the circulation in living Rhynchonellæ. This subject, and the circulation of Lingula, which has red blood, is reserved for discussion in a subsequent memoir. The digestive canal of the Brachiopods, as well as the circulatory system, does not compare well with those of the normal worms.

> "The anomalous features presented by some worms, in the absence of an anus, or the possession of a cœcal stomach, and the anterior termination of the anus, are fully repeated in the Brachiopoda. In one entire division of the Brachiopoda, represented by Terebratula, the stomach terminates in a cœcal sac. In Terebratulina the alimentary tract is closed posteriorly. Nor has the slightest trace of an anus been detected in Thecidium, Waldheimia, Rhynchonella, and several other genera that have been examined. In the very early stages of Terebratulina, I have seen the rejectamenta escape from the mouth, and in no case has the appearance of an anal perforation been discovered. In Terebratulina, the alimentary tract pursues a direct antero-posterior course without convolutions, while in Lingula and Discina the anus terminates anteriorly on the right side. In Lingula, the intestine makes a few turns, while in Discina it makes a single turn to the right."

The nervous system is much as in the worms, there being two lateral ventral cords, widely separated (in Lingula these lateral threads seem to be double and connected by commissures) and connected at the œsophagus by ganglionic enlargements, which send off threads to the pallial membranes, and to the various muscles. The breathing organs of Brachiopods are contained in the pallial membrane, which is divided into two oblique transverse sinuses, apparently resembling the interior of the branchia of a worm. The genital organs are almost identical with those of worms, as may be seen by a study of Figs. 30–40.

We now quote the author's conclusions in his own words: —

> "In considering the assemblage of remarkable characters in the Brachiopods, we must recognize in them a truly ancient type, and consequently a synthetic, or comprehensive type. Thus while we do not find them in all their characters resembling any one group of worms, I have endeavored to show that all their features, to a greater or less degree, are shared by one or the other of the various groups of the Vermes, with one or two features shared by the Arthropods.
>
> It is important to remark in this connection that most of the ancient groups differ from present groups with which they are associated. Thus the Trilobites are widely unlike modern Crustaceans, Milne-Edwards and Van Beneden suggesting their affini-

Fig. 30.

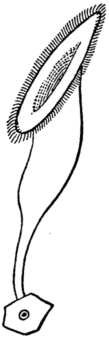


Fig. 31.

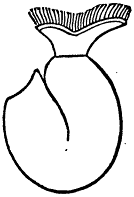


Fig. 32.

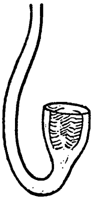


Fig. 33.

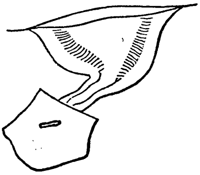
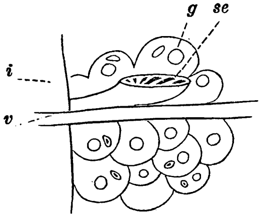


Fig. 34.



Segmental organs of worms.

Fig. 30, Lumbricus; Fig. 31, Pectinaria; Fig. 32, Eunice; Fig. 33, Stylodrilus; Fig. 34, Nereis; *se*, segmental organ, *g*, genitalia, *v*, vascular channel, *i*, intestine; Fig. 30 is from Lankester, the rest from Claparède.

Fig. 35.

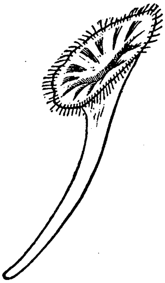


Fig. 36.

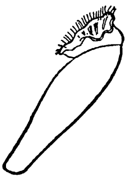


Fig. 37.

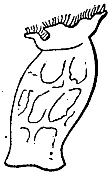
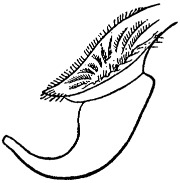


Fig. 38.



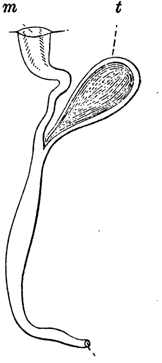
Segmental organs of the Brachiopods.

Fig. 35, Discina; Fig. 36, Lingula; Fig. 37, Rhynchonella; Fig. 38, Terebratulina. These figures are from Morse's own studies.

ties with the Arachnids. Tetrabranchiate Cephalopods are widely separated from the Dibranchiate Cephalopods. Crinoids are widely unlike modern Echinoderms. In other words, among the Mollusks, Echinoderms and Crustaceans are ancient types widely different from the modern types with which they are correlated.

So in worms we should expect to see ancient types, while presenting a high organization, yet differing from present groups to which they are unquestionably related. And from the high complication of structure of the Brachiopods, Tetrabranchiates, and other ancient types, it would seem that in their culmination in ancient times they had the same relation to animals living then as the higher groups of present times bear to their associates. As to the more ancient forms of Brachiopods, it is probable with them, as with other groups, that their lower members were soft-bodied, and the argument that has been urged, as militating against Darwin, that animals of high complication of structure occur in the older groups, becomes valueless, when we consider that the lower forms of their respective groups are more often soft-bodied, and that complicated forms of earlier times were also culminating forms of preëxisting groups. * * * * *

Fig. 39.



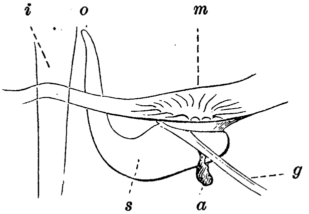
Segmental organ of *Alciope Cantrainii.*

m, inner mouth, of segmental organ; *o*, external orifice of ditto; *t*, testis.

To sum up the whole then :—ancient Chætopod worms culminated in two parallel lines, on the one hand in the Brachiopods, and on the other, in the fixed and highly cephalized Chætopods. The divergence of the Brachiopods, having been attained in more ancient times, a few degraded features are yet retained, whose relationships we find in the lower Vermes; while from their later divergence the fixed and cephalized Annelides are more closely allied to present free Chætopods.

And so we must regard the Brachiopods as *ancient cephalized Chœtopods*, while Serpula, Amphitrite, Sabella, Protula and others, may be regarded as *modern* (later) *cephalized Chœtopods*."

Fig. 40.



Segmental organ of Terebratulina.

s, segmental organ; *m*, inner mouth of ditto; *o*, external orifice of ditto; *g*, genital band; *a*, accessory vesicle; *i*, intestine.

Aside from the great interest of the memoir, the skilful and concise manner in which the facts, — many discovered by the author himself after the most patient study, which would in themselves commend the work to every one — are presented, we think the author has demonstrated, in the clearest manner, that the Brachiopods are worms. And we congratulate ourselves that this important discovery of the obscure relationship of these animals has been made by an American naturalist, with the advantages presented in this country.

Still, from the facts so clearly set forth, we doubt whether the Brachiopods should, even with all the important Chætopod characters they present, be included in the division of Chætopod worms, but rather look forward to their being united with the Polyzoa in a division equivalent, perhaps, to the rest of the worms, at least the Chætophora and Discophora combined, and forming a somewhat parallel group. The Brachiopods, certainly, from Prof. Morse's own showing, have not either such a nervous system, or respiratory or circulating organs, or an annulated body, as would warrant their union with the Chætopods. He has fully proved that they are a synthetic type, combining the features of different groups of worms and other articulate animals, and in doing so he virtually forbids our sharing his view as to their special Chætopod nature. We would prefer, in speculating on their ancestry, to derive the Brachiopods and Polyzoa from a common vermian ancestry, not much higher than the Rotifers, from which sprung two stems; one resulting in the Polyzoa, and the other in the more highly and specially-developed Brachiopods, while the Chætopods were probably derived independently from an ancestry higher perhaps, but vaguely resembling the Rotifers. As to the molluscan affinities of these animals, let those prove them who can, after going over step by step the track revealed by the patient and toilsome researches of our author.

NORTH AMERICAN GRASSHOPPERS.[*]—Dr. Hayden proposes to collect, in a single quarto volume, papers upon the zoology and botany of the Rocky Mountain region explored by him in his government surveys. The fishes and reptiles will be elaborated by Professor Cope, the botany by Professor Porter, Hemiptera by Mr. Uhler, Coleoptera by Dr. Horn, birds by Dr. Coues and mammals by Professor Gill. The first part, on a portion of the Orthoptera, is now published, and if the whole work is executed upon the same scale, one volume cannot contain it all: let us hope that it will not. In the part before us, Dr. Thomas does not

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[*] Report of the U. S. Geological Survey of the Territories. F. V. Hayden, Geologist in charge. Vol. v, Zoology and Botany. Part i, Synopsis of the Acrididæ of North America, by Cyrus Thomas, Ph.D. 4to. pp. x, 262. Washington, 1873.